

The electron emission efficiency can be improved by suitably adjusting the density of the fine particles.

The electron-emitting device having the semiconductor layer as illustrated in FIG. 17 makes it possible to lower the drive voltage by controlling the electrical resistance of the semiconductor, and also can be effective in improvement of emitted currents.

We claim:

1. A display device comprising:
an electron-emitting device, comprising a semiconductor formed between opposing electrodes and wherein fine particles are dispersed within said semiconductor or on said semiconductor; and
fluorescent members located at the inner side of a face plate above the electron-emitting device, wherein said fluorescent members emit light by a stimulation of the electrons emitted from said electron-emitting device.
2. The display device of claim 1, having the structure in which said fine particles are completely included into said semiconductor.
3. The display device of claim 1, having the structure that said fine particles are partly contained in said semiconductor and partly exposed therefrom.
4. The display device of claim 1, wherein said fine particles are made of a substance selected from the group consisting of borides, carbides, nitrides, metals, metal oxides, semiconductors, and carbon.
5. The display device of claim 4, wherein said fine particles comprise at least two kinds of different materials.
6. The display device of claim 4, wherein said fine particles are selected from the group consisting of Nb, Mo, Rh, Hf, Ta, W, Re, Pt, Ti, Au, Ag, Cu, Cr, Al, Co, Ni, Fe, Pb, Pd, Cs and Ba.
7. The display device of claim 4, wherein said fine particles comprise a metal oxide selected from the group consisting of In_2O_3 , SnO_2 , BaO , MgO and Sb_2O_3 .
8. The display device of claim 4, wherein said fine particles comprise Pd or SnO_2 .
9. The display device of claim 5, wherein said different materials comprise materials having different conductivities.
10. The display device of claim 1, wherein said fine particles are dispersed between said electrode by coating.
11. The display device of claim 1, wherein said fine particles are dispersed between said electrode by vacuum deposition.
12. The display device of claim 1, wherein said fine particles are dispersed by thermal decomposition of an organic metal compound.
13. The display device of claim 1, having the device structure in which the electrodes are formed on a substrate, the semiconductor is formed between said electrodes, and the fine particles are arranged inside or on said semiconductor in a dispersed state.
14. The display device of claim 1, where a plurality of said electron-emitting device are mounted on a single plane.
15. A display device comprising:
an electron-emitting device, comprising an insulating layer, is disposed between opposing electrodes on a planar substrate, and having fine particles arranged within said insulating layer in a dispersed state; wherein electrons are emitted by applying a voltage to said electrodes;
fluorescent members located at the inner face of a face plate disposed above the electron-emitting device, wherein said fluorescent members emit light by a stimulation of the electrons emitted from said electron-emitting device; and

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any of said fine particles is partly included into _____ partly exposed from said insulating layer.

16. The display device of claim 15, wherein said fine particles are dispersed between the electrodes by coating.

17. The display device of claim 15, wherein said fine particles are dispersed between the electrodes by vacuum deposition.

18. The display device of claim 15, wherein said fine particles are dispersed between the electrodes by thermal decomposition of an organic metal compound.

19. The display device of claim 15, wherein said fine particles are composed of a material selected from the group consisting of borides, carbides, nitrides, metals, metal oxides, semiconductors and carbon.

20. The display device of claim 19, wherein said material comprises a metal oxide selected from the group consisting of In_2O_3 , Sm_2O_3 , BaO , MgO and Sb_2O_3 .

21. The display device of claim 15, wherein said fine particles comprise at least two kinds of different materials.

22. The display device of claim 21, wherein said different materials comprise materials having different conductivities

23. The display device of claim 15, wherein said fine particles are composed of a material selected from the group consisting Nb, Mo, Rh, Hf, Ta, W, Re, Ir, Pt, Ti, Au, Ag, Cu, Cr, Al, Co, Ni, Fe, Pb, Pd, Cs and Ba.

24. The display device of claim 15, wherein said fine particles comprise Pd or SnO₂.

25. The display device of claim 15, comprising a substrate comprising a porous glass in which a metal or a metal oxide is deposited.

26. The display device of claim 15, comprising a colored glass containing metal colloid fine particles.

27. A display device comprising:

an electron-emitting device, comprising opposing electrodes formed on an insulating layer disposed on a planar substrate, and fine particles being dispersed within said insulating layer between said electrodes;

fluorescent members located at the inner side of a face plate disposed above the electron-emitting device, wherein said fluorescent members emit light by a stimulation of the electrons emitted from said electron-emitting device; and

said fine particles are so structured that any of said fine particles are partly included into and partly exposed from said insulating layer.

28. The display device of claim 27, wherein said insulating layer comprises a low-melting glass.

29. The display device of claim 27, wherein said insulating layer has a film thickness of from several ten angstroms

to several ten microns.

36
The display device of claim 27, wherein said particles are composed of a material selected from the group consisting of borides, carbides, nitrites, metals, metal oxides, semiconductors and carbon.

31. The display device of claim 30, wherein said fine particles material comprises a metal oxide selected from the group consisting of In_2O_3 , SnO_2 , BnO , MgO and Sb_2O_3 .

32. The display device of claim 27, wherein said fine particles comprise at least two kinds of different materials.

33. The display device of claim 27, wherein said different materials comprise materials having different conductivities.

34. The display device of claim 27, wherein said fine particles are composed of a material selected from the group consisting of Nb, Mo, Rh, Hf, Ta, W, Re, In, Pt, Ti, Au, Ag, Cu, Cr, Al, Co, Ni, Fe, Pb, Pd, Cs and Ba.

35. The display device of claim 27, wherein said fine particles comprise Pd or SnO_2 .

36. A display device comprising:

a face plate;

an electron-emitting device, comprising opposing electrodes disposed on a planar insulating substrate, and fine particles being dispersed between said opposing electrodes and being partly included into said planar insulating substrate, wherein electrons are emitted by applying a voltage to said electrodes; and

fluorescent members located at the inner side of said face plate above the electron-emitting device, wherein said fluorescent members emit light by a stimulation of the electrons emitted from said electron-emitting device.

37. The display device of claim 36, wherein said fine particles are selected from the group consisting of borides, carbides, nitrites, metals, metal oxides, semiconductors and carbon.

38. The display device of claim 37, wherein said fine particles comprise a metal oxide selected from the group consisting of In_2O_3 , SnO_2 , BaO , MgO and Sb_2O_3 .

39. The display device of claim 36, wherein said fine particles comprise at least two kinds of different materials.

40. The display device of claim 39, wherein said different materials comprise different materials having different conductivities.

41. The display device of claim 36, wherein said fine particles are selected from the group consisting of Nb, Mo, Rh, Hf, Ta, W, Re, Ir, Pt, Ti, Au, Ag, Cu, Cr, Al, Co, Ni, Fe, Pb, Pd, Cs and Ba.

42. The display device of claim 36, wherein said fine particles comprise Pd or SnO_2 .

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43. A display device comprising:

an electron source plate formed as a laminated structure, said electron source plate including:

a substrate,

a first electrode disposed on the substrate,

an intermediate member disposed on said first electrode, and having a side wall which includes an electron-emission layer containing an electrical discontinuity,

a second electrode spaced from said substrate in a direction normal to said substrate, and

voltage application means for applying a voltage across the first and second electrodes to generate an electric field across a surface of the electron-emission layer for causing the electron-emission layer to emit an electron; and

a fluorescent device plate including:

a transparent substrate.

a fluorescent layer.

an acceleration electrode, and

means for applying an acceleration

voltage to the acceleration electrode

wherein the electron source plate and the
fluorescent device plate form a vacuumed housing wall of the
display device.

44. The display device of Claim 43, wherein said electron-emission layer comprises a conductive region and an insulating region.

45. The display device of Claim 43, wherein said electron-emission layer contains carbon.

46. The display device of Claim 43, wherein an end of one of the first and second electrodes is flush with the sidewall of the intermediate member.

47. A display apparatus comprising:

an electron source plate including:

a substrate,

an insulating member arranged on the substrate so that an end of the insulating member forms a sidewall on the substrate,

an electron-emission layer containing an electrical discontinuity, and being disposed on the sidewall of the insulating member for emitting electrons upon an application of an electric field across a surface of the electron-emission layer, and

voltage application means for generating an electric field across the surface of the electron-emission layer; and

a fluorescent device plate including:

a transparent substrate,

a fluorescent layer,
an acceleration electrode, and
means for applying an acceleration
voltage to the acceleration electrode,
wherein the electron source plate and the
fluorescent device plate form a vacuumed housing wall of the
display apparatus.

48. The display apparatus of Claim 47, wherein
said voltage application means has a pair of electrodes
including an upper electrode positioned at an upper part of
the sidewall of the insulating member and a lower electrode
positioned at a lower part of the sidewall of the insulating
member, and wherein said voltage application means generates
the electric field across the surface of the electron-
emission layer.

49. The display apparatus of Claim 47, wherein
said electron-emission layer comprises a conductive region
and an insulating region.

50. The display device of Claim 47, wherein said electron-emission layer contains carbon.

51. A display apparatus comprising:
an electron source plate including:
a substrate, and

a plurality of electron emission elements arranged in a matrix of rows and columns on said substrate, each electron emission element being formed in a laminated structure and comprising:

a first electrode disposed on the substrate,

an intermediate member disposed on said first electrode, and having a side wall which includes an electron-emission layer containing an electrical discontinuity, wherein the electron-emission layer emits an electron upon an application of a voltage across a surface thereof, and

a second electrode spaced from said substrate in a direction normal to said substrate;

a matrix wiring configuration comprising row wirings and column wirings respectively corresponding to the rows and columns of the electron emission elements arranged in the matrix;

drive means for applying (i) a scan signal to the row wirings, (ii) a modulation signal to the column wirings corresponding to the scanned electron emission elements, and (iii) a low voltage across the first and second electrodes of each of the electron emission elements; and

a fluorescent device plate including:

a transparent substrate,

a fluorescent layer,

an acceleration electrode, and

means for applying an acceleration
voltage to the acceleration electrode,
wherein the electron source plate and the
fluorescent device plate form a vacuumed housing wall of the
display device.

52. The display apparatus of Claim 51, wherein
said drive means simultaneously applies the modulation signal
to the electron emission elements on a selected row in
synchronization with the scan signal.

53. A display apparatus comprising:
an electron source plate including:
a substrate, and
a plurality of electron emission elements
arranged in a matrix of rows and columns on said substrate,
each electron emission element including:
an insulating member arranged on the
substrate so that an end of the insulating member forms a
sidewall on the substrate, and
an electron-emission layer
containing an electrical discontinuity, and being disposed on
the sidewall of the insulating member for emitting electrons
upon an application of a voltage across a surface of the
electron-emission layer;
a matrix wiring configuration which comprises
row wirings and column wirings respectively corresponding to

the rows and columns of the electron emission elements arranged in the matrix;

drive means for applying (i) a scan signal to the row wirings, (ii) a modulation signal to the column wirings corresponding to the scanned electron emission elements, and (iii) a voltage to the electron-emission layer of the electron emission element; and

a fluorescent device plate including:

a transparent substrate,

a fluorescent layer,

an acceleration electrode, and

means for applying an acceleration voltage to the acceleration electrode,

wherein the electron source plate and the fluorescent device plate form a vacuumed housing wall of the display device.

54. The display apparatus of Claim 53, wherein said drive means simultaneously applies the modulation signal to the electron emission elements on a selected row in synchronization with the scan signal.

55. The display apparatus of Claim 53, wherein said drive means has a pair of electrodes including an upper electrode positioned at an upper part of the sidewall of the insulating member and a lower electrode positioned at a lower part of the sidewall of the insulating member, and wherein

said drive means generates the electric field across the surface of the electron-emission layer.

56. A display apparatus comprising:

an electron source plate including:

a substrate, and

a plurality of electron emission elements

arranged in a matrix of rows and columns on said substrate, each electron emission element including:

a first electrode disposed on said substrate,

a second electrode disposed on said substrate, and

an electron-emission layer

containing an electrical discontinuity, said electron-emission layer for emitting an electron upon an application of a voltage across said first and second electrodes;

a matrix wiring configuration comprising row wirings and column wirings respectively corresponding to the rows and columns of the electron emission elements arranged in the matrix;

drive means for applying (i) a scan signal to the row wirings, (ii) a modulation signal to the column wirings corresponding to the scanned electron emission elements, and (iii) a voltage across the first and second electrodes of the electron emission element; and

a fluorescent device plate including:

1

a transparent substrate,
a fluorescent layer,
an acceleration electrode, and
means for applying an acceleration
voltage to the acceleration electrode,
wherein the electron source plate and the
fluorescent device plate form vacuumed housing walls of the
display device.

57. The display apparatus of Claim 56, wherein
said modulation signal is made according to an information
signal.

58. The display apparatus of Claim 56, wherein
said electron-emission layer comprises a conductive region
and an insulating region.

59. The display apparatus of Claim 56, wherein
said electron-emission layer contains carbon.

60. The display apparatus of Claim 56, wherein
said acceleration voltage is in the range of 0.8kV to 1.5kV.

61. The display apparatus of Claim 56, wherein
said drive means simultaneously applies the modulation signal
to the electron emission elements on a selected row in
synchronization with the scan signal.

62. The display apparatus of Claim 56, wherein ends of said first and second electrodes are disposed in a lateral direction at least roughly parallel to the surface of the substrate and face each other, and said electron-emission layer is disposed between the ends of those electrodes.

63. The display apparatus of Claim 62, wherein said drive means applies the voltage across the electrodes to generate an electric field across the surface of the electron-emission layer.

64. The display apparatus of Claim 56, wherein said voltage applied across said first and second electrodes is less than or equal to 32 Volts.